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PLATE IV. Fig. 6. *Desmophyllum Stellaria*, Ehrenberg. Nat. size, sitting on *Nullipora Lithophyllum expansum*, Phil.

XV.—*Thoughts on the Equivocal Generation of Entozoa*. By JAS. L. DRUMMOND, M.D., Professor of Anatomy and Physiology in the Royal Belfast Institution, &c.

IN studying the *Entozoa*, one of the first things which demands our attention, is the peculiarity of the situations which they occupy. When we look abroad upon the features of the globe which we inhabit, we find that every part is filled with animal and vegetable life; whether we visit the frozen regions of the poles, or the countries for ever exposed to the heat of an equatorial sun, we see that every clime has its animals and plants, and these in general, so constituted in their structure and œconomy, as to be fitted peculiarly for the circumstances of the place in which they reside. The White Bear delights in the perennial snows and ice of its native region, and the Lion in the fervour of the torrid zone; but were they to change situations, the former would die from the excessive heat, and the latter would as certainly perish from the intolerable cold.

And so it is with the *Entozoa*; they have been ordained to inhabit, alone, the interior of other animals; and though many of them will live for several days when removed from that situation and put in water, yet that can only be deemed a lingering death, for at length they infallibly perish from the unnatural circumstances in which they are placed. It has been asserted, indeed, that some of the intestinal worms have been found living in other situations. Thus, Linnæus supposed that the Fluke-worm (*Distoma hepaticum*) was to be found in fresh water, as also the common Tape-worm in muddy pools, and the *Ascaris vermicularis* in marshes among the roots of decaying plants. (Rudolphi, i. 371.) But it has been shown by Muller and Rudolphi, that he had mistaken other external species of animals for true *Entozoa*; that his supposed *Tænia* and Fluke-worm were the *Planaria lactea*, and his *Ascaris vermicularis* a quite different animal.

But even admitting that a true entozoon should be found in a pool or rivulet of fresh water, still something more would be necessary to prove that such was its natural habitat. Every one knows that when an animal is infested with Tape-worm, portions of the latter are frequently ejected along with the

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alvine excretions, and therefore the circumstance of a specimen being found in water inhabited by fish of any kind may amount only to this, that it had originally belonged to the fish. Thus the celebrated Muller, when travelling on the borders of Sweden, was told of a rivulet in which *Tæniæ* were to be found; he visited it accordingly, and satisfied himself that the account was true, by taking out of its water bundles of dead Tape-worms coiled together. But what then? Did he find anything more? Yes, he found quantities of the intestines of fish which had been thrown in by the fishermen, which fairly accounted for the presence of the worms. (Rud. i. 373*.) No one who has been in the practice of examining the intestines of fishes in pursuit of their living contents, will be surprised at this account, since the quantity of tape-worm sometimes found in them is often almost incredible. Thus in a salmon of eleven pounds weight, in July, 1838, I found a number of *Bothriocephali*, the longest of which was four feet ten inches, and their united lengths amounted to upwards of fifty-nine feet. In the common Cod their number is often very great, and in a middle-sized turbot I have found upwards of two hundred specimens of the *Bothriocephalus punctatus*, each measuring from ten to eighteen inches in length.

It would be unnecessary to dwell longer on this subject, as I believe all Helminthologists, and all who have considered it, are fully agreed that the *Entozoa* have their natural abode in the animal body alone, and that in any other situation they infallibly perish. But the more difficult question is, *how do they get there?*

This query cannot at present be satisfactorily solved, for the truth is that we know nothing of their origin; but I am not inclined therefore to suppose them to be the entities of equivocal generation, a doctrine still indulged in by naturalists and physiologists of high name and authority, and which formerly was generally embraced with regard to all animals occupying the lower links in the great chain of animated being.

But as the light of science burned bright, innumerable errors were by slow degrees seen into, and have long since ceased to blot the page of truth. They arose out of ignorance; and to a similar origin we are, I believe, to attribute the theory of equivocal generation, whether it be applied to a fungus,

* At a place about a quarter of a mile beyond Belfast Bridge, on Ballymacarret Strand, where worn-out horses are slaughtered, I have more than once seen dead *Tæniæ* in a pool of water, but there could be no doubt that their original habitat had been the intestines of the slaughtered animals, dragged to the said pool by dogs, or kicked into it by idle boys.—J. L. D.

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an animalcule, or an entozoon. We know not how a mucor originates on a decaying vegetable or animal matter, nor how millions of animalcules appear in a vegetable infusion, nor how an entozoon shows itself in the intestines or the brain of an animal; but because we do not in our present state of knowledge understand these things, are we to fall into the error of the ancients, and attempt to explain, by what seems next to an impossibility, their appearance on the supposition of a spontaneous generation? Some of these obscure animals have an organization so perfect and admirable, that to me it would seem almost as consonant to reason and sense to attribute the formation and œconomy of an elephant, or I might say, of man himself, to equivocal generation, as theirs.

To some, however, there seems to be no difficulty in the matter; and it is stated with great confidence, that because a clot of effused lymph from an inflamed serous surface becomes organized and sensible, so it is quite easy to conceive that a living worm may be equally produced from unorganized matter; the only difference between the two being this,—that the organized lymph continues adherent to the matrix, while the other is cast off as a separate being.

But that the analogy between an organized portion of lymph and an entozoon is extremely remote, can, I think, be easily shown; there is, indeed, a gap between them which can never be filled up. In the first place, the effused lymph in the example alluded to, however organized it may be, is a constituent, though I grant an unnecessary and superfluous part, of the body to which it is attached; but it is a natural product of that law of the animal œconomy, by which it throws out lymph from inflamed serous membranes, and from the sides of wounds, into which the vessels pullulate for the purpose of uniting the dissevered or adjacent surfaces. It is, in fact, a product of the adhesive action, or adhesive inflammation, as the common term is, and has no life whatever independently of the life of the part on which it is situated. However extraneous or unnecessary to the animal which has produced it, it has no vitality independent of the life of that animal of which it is now an integrant part, and its separation from which is its immediate death.

Again, I would remark, that no growth from effused lymph is ever seen showing any mark of independent life, or in the state of passing from a dependent to an independent vitality. No instance has ever occurred of effused lymph, however organized it may have become, exhibiting, as in the postic fictions of the animals formed from the mud of the Nile, one part as merely organized lymph, and another assuming the

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form and functions of a worm. Nor further, has any entozoon been found in a semi-state of formation. There is never any intermediate stage in which it can be shown that the animal is in its transit from an accidental origin to the more perfect state, in which it shall exhibit a complex and independent organization, and like other animals, have organs for the continuation of its species. It would, indeed, require no inconsiderable stretch of imagination to conceive that a portion of effused lymph could assume to itself the power of producing other similar, or rather very dissimilar portions, which would propagate their kind from generation to generation, in *sæcula sæculorum*; for I incline to the belief that the *Tæniæ* and *Lumbrici* of Hippocrates were as much the progenitors of those found at the present day, as were the men and women of his time the ancestors of those now living in the nineteenth century.

In considering the formation of any animal, we cannot move a step without reference to an all-powerful architect; in every structural part, in every function, in every action, in every instinct of such animal, we perceive so great a degree of contrivance, creative power and wisdom, that the conviction is forced upon us that these cannot be the work of chance, that "there cannot be design without a designer; contrivance, without a contriver; order, without choice; arrangement, without anything capable of arranging; subserviency and relation to a purpose, without that which could intend a purpose; means suitable to an end, and executing their office in accomplishing that end, without the end ever having been contemplated, or the means accommodated to it*." Yet, in the doctrine of spontaneous generation all these are dispensed with; we have "contrivance without a contriver, and design without a designer," and a number of atoms collected together form themselves into wonderfully fabricated and sentient beings, independent of those conditions by which other organized bodies are produced. An insensible mass of matter will, we know, become developed into a living being of most complicated structure and wonderful œconomy; an egg will be hatched into a peacock, but the egg could never have existed but for its female parent, nor could it ever be hatched into the living bird without having received the permanent vital principle from its male progenitor, in obedience to those laws ordained by the Deity when the first male and female peacock were created; but the beings of equivocal generation are independent of all such laws; of the contrivance which they display

* Paley's Natural Theology.

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In considering the formation of any animal, we cannot move a step without reference to an all-powerful architect; in every structural part, in every function, in every action, in every instinct of such animal, we perceive so great a degree of contrivance, creative power and wisdom, that the conviction is forced upon us that these cannot be the work of chance, that "there cannot be design without a designer; contrivance, without a contriver; order, without choice; arrangement, without anything capable of arranging; subserviency and relation to a purpose, without that which could intend a purpose; means suitable to an end, and executing their office in accomplishing that end, without the end ever having been contemplated, or the means accommodated to it*." Yet, in the doctrine of spontaneous generation all these are dispensed with; we have "contrivance without a contriver, and design without a designer," and a number of atoms collected together form themselves into wonderfully fabricated and sentient beings, independent of those conditions by which other organized bodies are produced. An insensible mass of matter will, we know, become developed into a living being of most complicated structure and wonderful œconomy; an egg will be hatched into a peacock, but the egg could never have existed but for its female parent, nor could it ever be hatched into the living bird without having received the permanent vital principle from its male progenitor, in obedience to those laws ordained by the Deity when the first male and female peacock were created; but the beings of equivocal generation are independent of all such laws; of the contrivance which they display

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they themselves are the contrivers, of the design the designers.

Let us then suppose that a portion either of effused lymph or extravasated blood, or any other substance, is about to go through the process of converting itself into an intestinal worm, and consider what it has to do to effect so complete a metamorphosis; we must suppose that before it assumed its independent and distinct life, the first object would be to form for itself a mouth and an alimentary canal for its future support, a gastric juice of course, and the other necessaries for the function of digestion; now even this, in a particle of matter destitute of mind or intelligence, as is the peacock's egg, would seem to border a little on the miraculous.

Well, then, having provided for what many consider the most important business of life, the eating function, what has it to do next? Why to shake off the homely and ungraceful form of its embryotic clot, and assume the elegant gracility of an ascarid, or a *Spiroptera*, or the broad and jointed amplitude of a tape-worm, the polymorphous structure of a *Scolex*, or the inextricable complexity of a *Distoma*.

Having settled this point, the clot has next to regulate its growth; clots are of very various dimensions, but the *Entozoa* are as certainly defined in their limits of magnitude as any other class of animals. Well, then, it must be obvious, that a clot larger than the species into which it is to be converted must fine itself down to the proper size, or if too small, plump itself up to the same; but by what mysterious power it can do this I profess not to understand.

Having got so far, however, in its own creation, what has it next to do? To cover itself with a proper skin; and in this great taste is often exhibited, the integument of many worms offering a very beautiful appearance; and observe the wonderful phenomenon connected with this. The Deity has spread over the surface of animals and plants (I mean such as He is acknowledged to have formed) an insensible covering, the cuticle, to serve as a protection for the parts beneath. And what does the clot do? Why just the same thing; it covers itself with a cuticle too; though indeed we need not wonder much at this, after its having made for itself an alimentary canal and bestowed upon it the function of digestion.

But the work is not yet completed; motion is not yet provided for, a muscular apparatus is therefore next to be fabricated; first, for the motion of the whole body, and next, for that of individual parts; and so perfectly is this accomplished, that it often forms a source of disappointment and vexation to the investigator of these animals. Some of the nematoid

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worms roll themselves up so pertinaciously by the action of their longitudinal muscles, that it is with the utmost difficulty the ends of the animal can be so straightened as to be distinctly seen; and the muscles of the head and bothria in some species, as in several of the *Bothriocephali*, and particularly in the *Scolex polymorphus*, are in such perpetual activity, and cause so many changes of figure, that hours at the microscope are necessary before we can obtain a satisfactory knowledge of the structure of the head.

It so happens that some species have a much smaller muscular strength and activity than others, as, for instance, the *Echinorhynchi*; and these might be readily carried through the alimentary canal of the animal in which they reside, had they their muscular power alone to trust to. And how does the clot provide for this? It forms a trunk or proboscis of exquisite workmanship, which it arms on all sides with sharp horny hooks; it forms muscles for the especial purpose of pushing out this proboscis, and others for drawing it in at pleasure into a sheath specially provided for it; moreover, this proboscis is so fashioned that it can be inverted or everted upon itself, that is, it can be pushed out or retracted as a snail does its horn, without which second kind of motion it would be imperfect; and thus by its twofold motion and its armament of rigid hooks, the proboscis is harpooned into the mucous coat of the intestine at the pleasure of the worm, which latter is thereby secured from removal by the pressure of the passing contents of the bowel. Some species, not content with one proboscis, provide themselves with four, and these in some of the armed *Bothriocephali* present one of the most beautiful microscopic objects to be found in nature.

But the work is not yet complete; sensation is further wanted. We are to suppose, that as the animal has acquired a digestive apparatus, it has superadded to this the sense of taste; but at all events it has the sense of touch, and therefore has provided for itself a system of nerves; for without a nervous system in some form or another, none, I presume, will insist that there can be sensation. With regard to the sense of smelling I say nothing; and persons who consider such subjects, would perhaps be of opinion that the entozoic life would be as comfortable without as with that sense. But as respects seeing, since organs of vision would be altogether superfluous in habitats where midnight darkness holds perpetual reign, we find accordingly that in no instance have the *Entozoa* provided themselves with eyes.

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structure, with its organic and animal life, its digestive, motive, and sensitive organs and functions, feels quite comfortable, and wishes to perpetuate its happiness in the continuation of its race or family to future individuals like itself, that it possesses the phrenological organ of philoprogenitiveness, —what will it do?

It will do this, what the Creator has done with the creatures formed by his own hand; it will provide itself with ovaries for containing eggs, the germs of future beings like itself; but how it is to form these, and how it is to impart to them the capability of being hatched into the identical resemblance of their parent, I pretend not to explain.

But we know that even when eggs are formed there is a very essential requisite necessary for bringing them into active life. They must have a certain vivifying power, without which they will remain as dead matter, and the fond hopes of the maternal parent will be frustrated unless this vital influence can somehow or other be procured. The task, then, next to be accomplished, is to provide this male influence; and we find that many species are androgynous, that is, the clot having produced its ovaries and ova, next fabricates organs for secreting the vivifying fluid, by whose presence the ova shall obtain the power of being developed into worms of the same formation and structure as their wonder-working parent.

Yet surprising as all this may appear, the climax is not yet arrived at. The *Ascarides* and some other genera are not androgynous or hermaphrodite, but distinctly male and female. Now on the principle of equivocal generation, it must be evident that the effused lymph or clot has the power of metamorphosing itself not only into a worm, but into a worm of either sex, as it may choose to determine; and it is equally obvious, that two clots must consult together in order to determine into what species they shall by mutual agreement become transformed. This must be absolutely necessary; there must be a predetermined arrangement between the two; for without this millions of males might be formed without one corresponding female, and millions of females be condemned to live and die in single blessedness.

These and many other wonders, or rather impossibilities, we must have recourse to, in order to support the theory of spontaneous generation; a theory which, in my mind, is as inconsistent with all that we observe of the operations of nature, as those which in the days of ignorance taught that putrid flesh of itself generated bees, that vapour influenced by an east wind changed into *Aphides*, and that the *Lepas anatifera* grew upon trees, and dropping into the sea became at length the barnacle goose.

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structure, with its organic and animal life, its digestive, motive, and sensitive organs and functions, feels quite comfortable, and wishes to perpetuate its happiness in the continuation of its race or family to future individuals like itself, that it possesses the phrenological organ of philoprogenitiveness, —what will it do?

It will do this, what the Creator has done with the creatures formed by his own hand; it will provide itself with ovaries for containing eggs, the germs of future beings like itself; but how it is to form these, and how it is to impart to them the capability of being hatched into the identical resemblance of their parent, I pretend not to explain.

But we know that even when eggs are formed there is a very essential requisite necessary for bringing them into active life. They must have a certain vivifying power, without which they will remain as dead matter, and the fond hopes of the maternal parent will be frustrated unless this vital influence can somehow or other be procured. The task, then, next to be accomplished, is to provide this male influence; and we find that many species are androgynous, that is, the clot having produced its ovaries and ova, next fabricates organs for secreting the vivifying fluid, by whose presence the ova shall obtain the power of being developed into worms of the same formation and structure as their wonder-working parent.

Yet surprising as all this may appear, the climax is not yet arrived at. The *Ascarides* and some other genera are not androgynous or hermaphrodite, but distinctly male and female. Now on the principle of equivocal generation, it must be evident that the effused lymph or clot has the power of metamorphosing itself not only into a worm, but into a worm of either sex, as it may choose to determine; and it is equally obvious, that two clots must consult together in order to determine into what species they shall by mutual agreement become transformed. This must be absolutely necessary; there must be a predetermined arrangement between the two; for without this millions of males might be formed without one corresponding female, and millions of females be condemned to live and die in single blessedness.

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And why should we have recourse to this theory of equivocal generation in order to account for the formation of the *Entozoa*? Precisely for the same reason that our progenitors indulged in the erroneous notions alluded to. They cherished the absurdity, because they were ignorant of the truth. They did not know that insect ova were hatched into maggots, and that maggots change into flies; and as the place of breeding of the barnacle was not known, they were determined to give it some origin, and they did so on grounds just as valid as those on which some modern physiologists rest the spontaneous origin of entozoic worms. The tentacula of the *Lepas* resemble feathers; why then should the shell not grow up to be a goose? An effused clot of lymph will become organized; why then should it not grow into a Tape-worm? The reasoning on the one side is just as good as on the other; but we may hope that a time will come when we shall have as direct proof of the origin of the entozoon as we have of that of the barnacle. At present, it is true, we are completely in the dark respecting the origin of worms in the interior of other animals; but it is better, more philosophical, more like genuine disciples of truth, to confess our ignorance, than to adopt a theory which is in direct opposition to what occurs in every department of organized nature with which we are properly acquainted.

For my own part, I can no more conceive that *Entozoa* are the creatures of chance than the animals they inhabit; though as to the manner of their origin, of which so little as yet is known, I pretend to go no further than is expressed in the old distich,—

The things we know are neither strange nor rare,
But wonder how the devil they got there.

Got there as they will, however, their possession of a distinct and independent life, their having sensation, voluntary motion, generative organs and functions, a digestive apparatus and other attributes of animals, while they exhibit the most minute, elaborate and exquisite workmanship, and also display the most unquestionable proofs of their whole composition, both general and partial, having been fabricated with the utmost wisdom and adaptation to their mode of life, show as clearly as if the proofs were written with a sunbeam, that they cannot be beings of fortuitous origin; that they are the offspring and work of the same Almighty hand which formed all the other races of animated being; and that to suppose their admirable formation to be the result of a kind of chance, is to impart to unintelligent matter that power and wisdom which belong only to the Deity himself.

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